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(54) **TOP DRIVE BACK-UP WRENCH WITH THREAD COMPENSATION**

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Related U.S. Application Data

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E21B 19/16 (2006.01)
E21B 3/02 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 19/16*** (2013.01); ***E21B 3/022*** (2020.05); ***E21B 19/163*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 19/16; E21B 19/163; E21B 3/02
See application file for complete search history.

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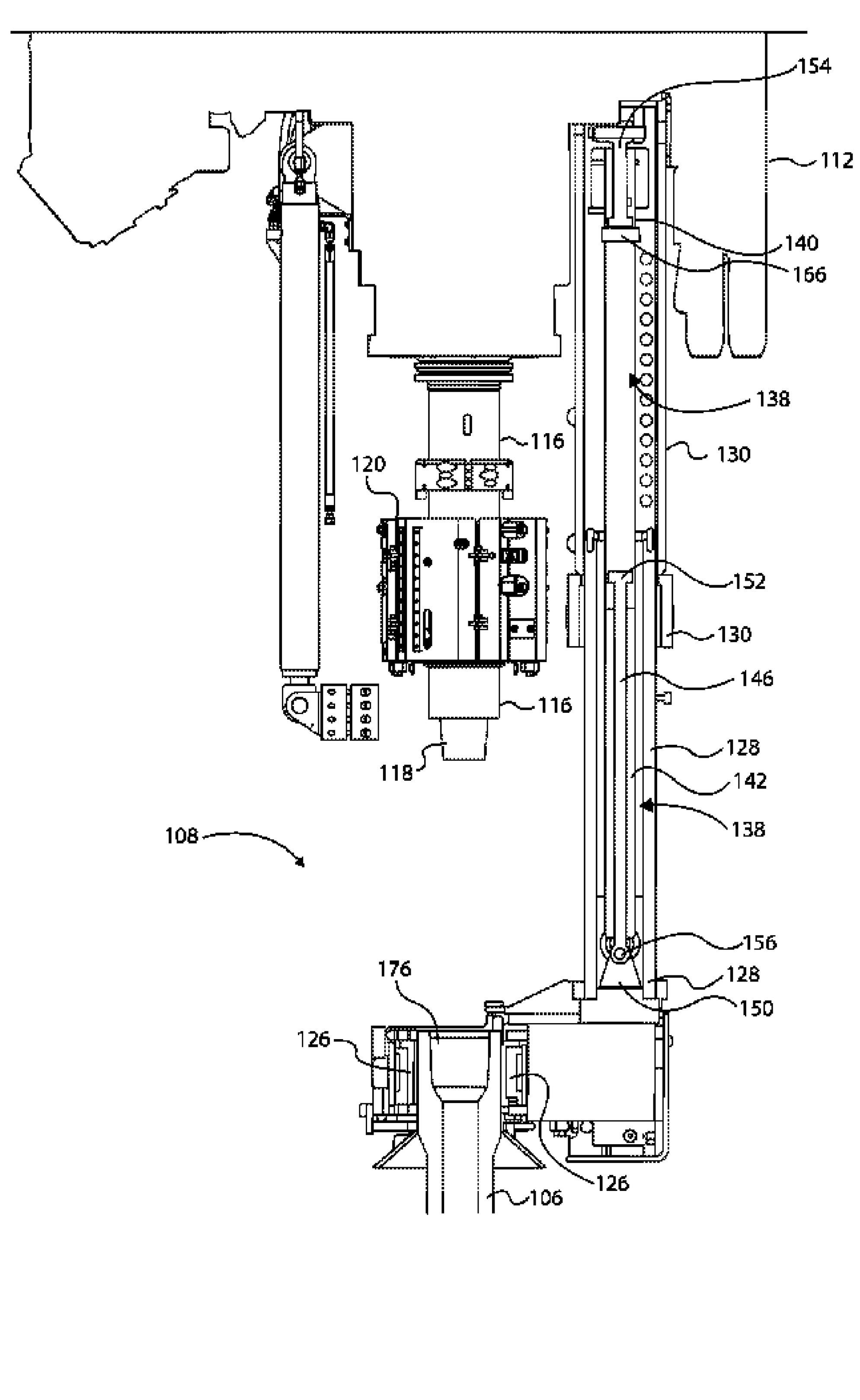
(57) **ABSTRACT**

A back-up wrench device of a top drive assembly of a drilling rig comprises a gripper device operable to grip an end of a drill pipe, and at least one fluid actuator operable to compensate for thread travel during makeup or breakout operations. The back-up wrench device can comprise a first housing coupled to the gripper device and a second housing coupled to a support structure of the top drive assembly, and can comprise a primary hydraulic housing movably coupled to the first and second housings. The at least one fluid actuator can include upper and lower fluid actuators each movable through upper and lower fluid chambers of the primary hydraulic housing during respective makeup and breakout operations to compensate for thread travel. Associated systems and methods for thread compensation with the back-up wrench are provided.

13 Claims, 10 Drawing Sheets



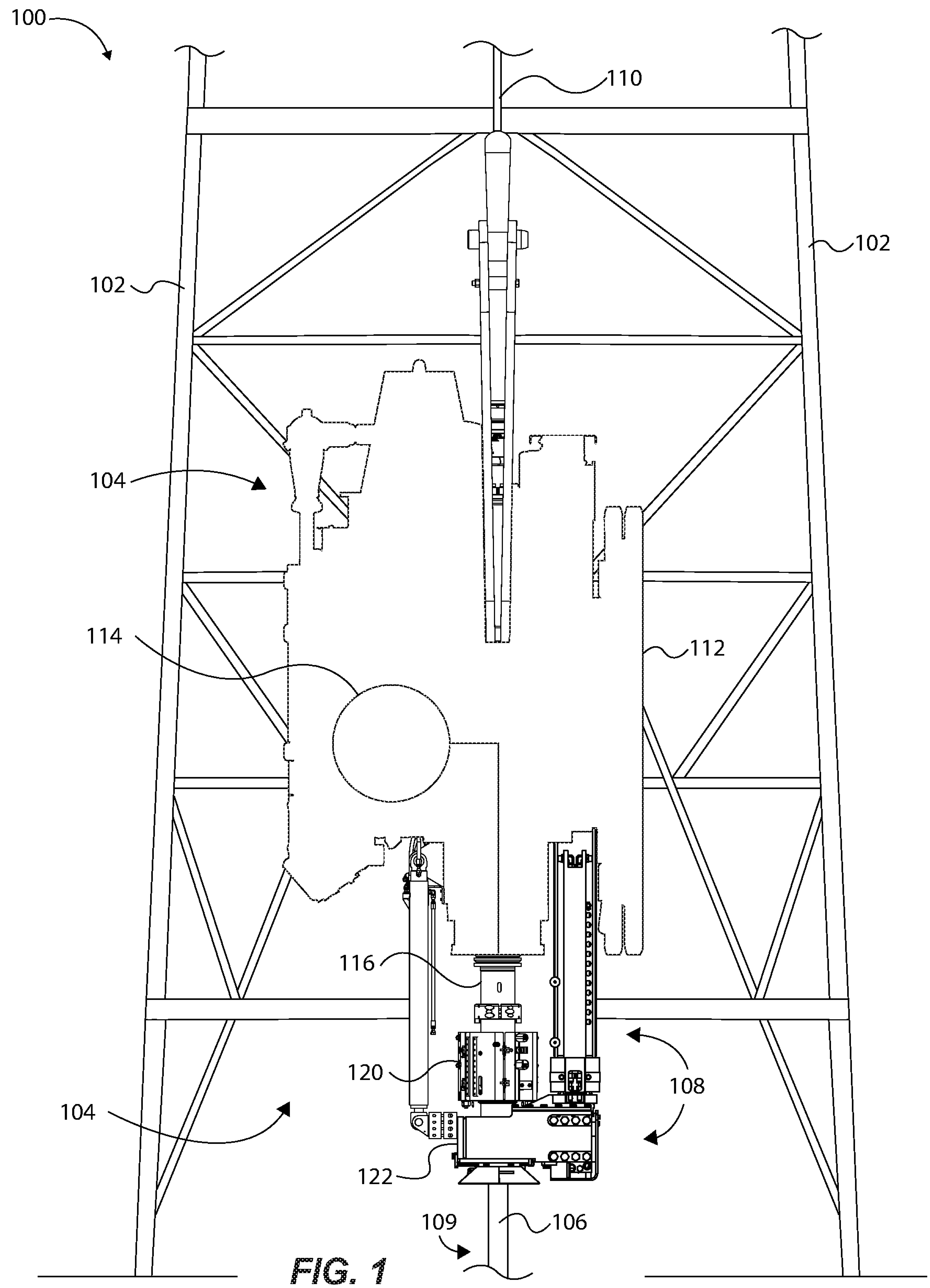


FIG. 1

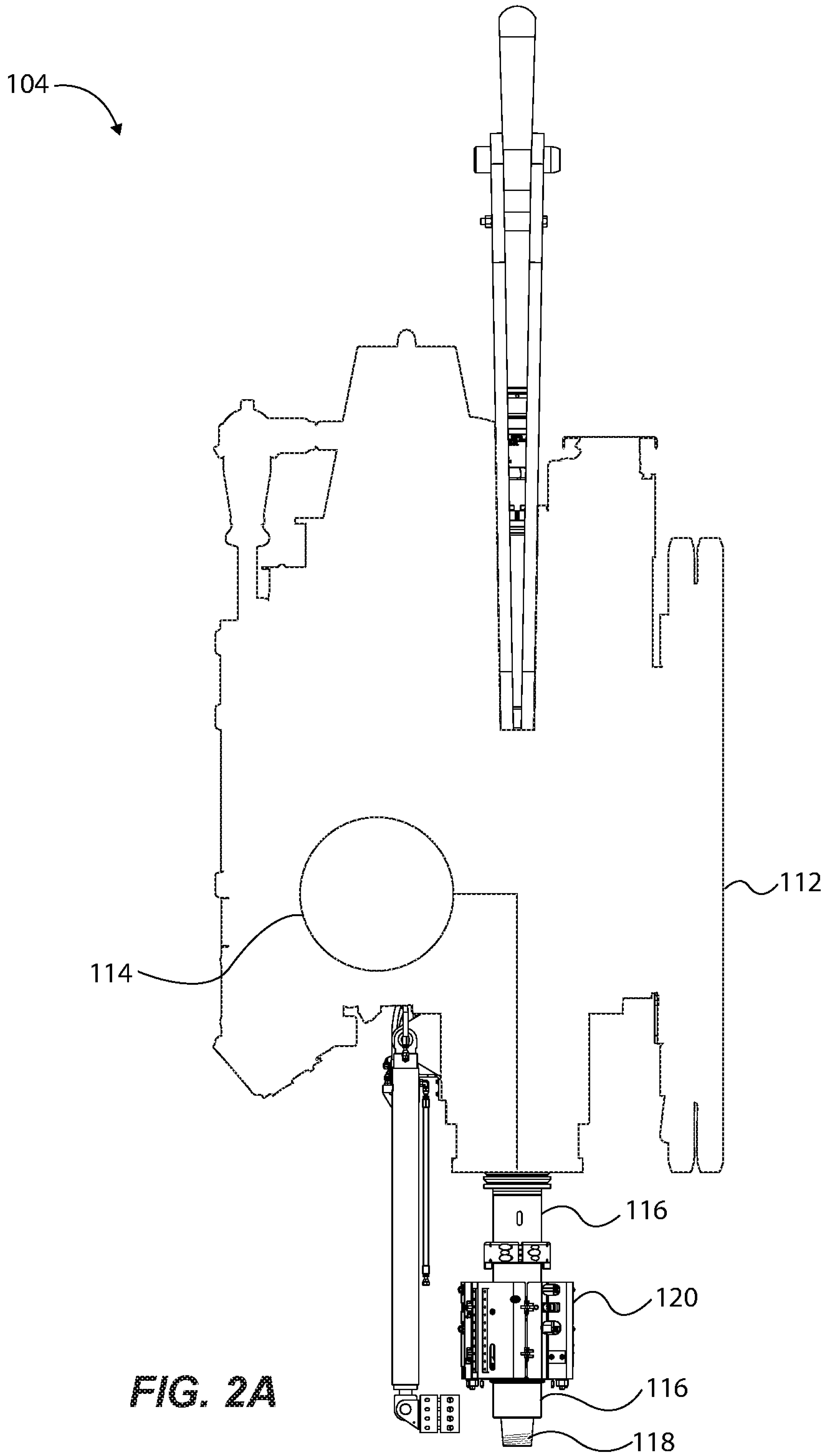


FIG. 2A

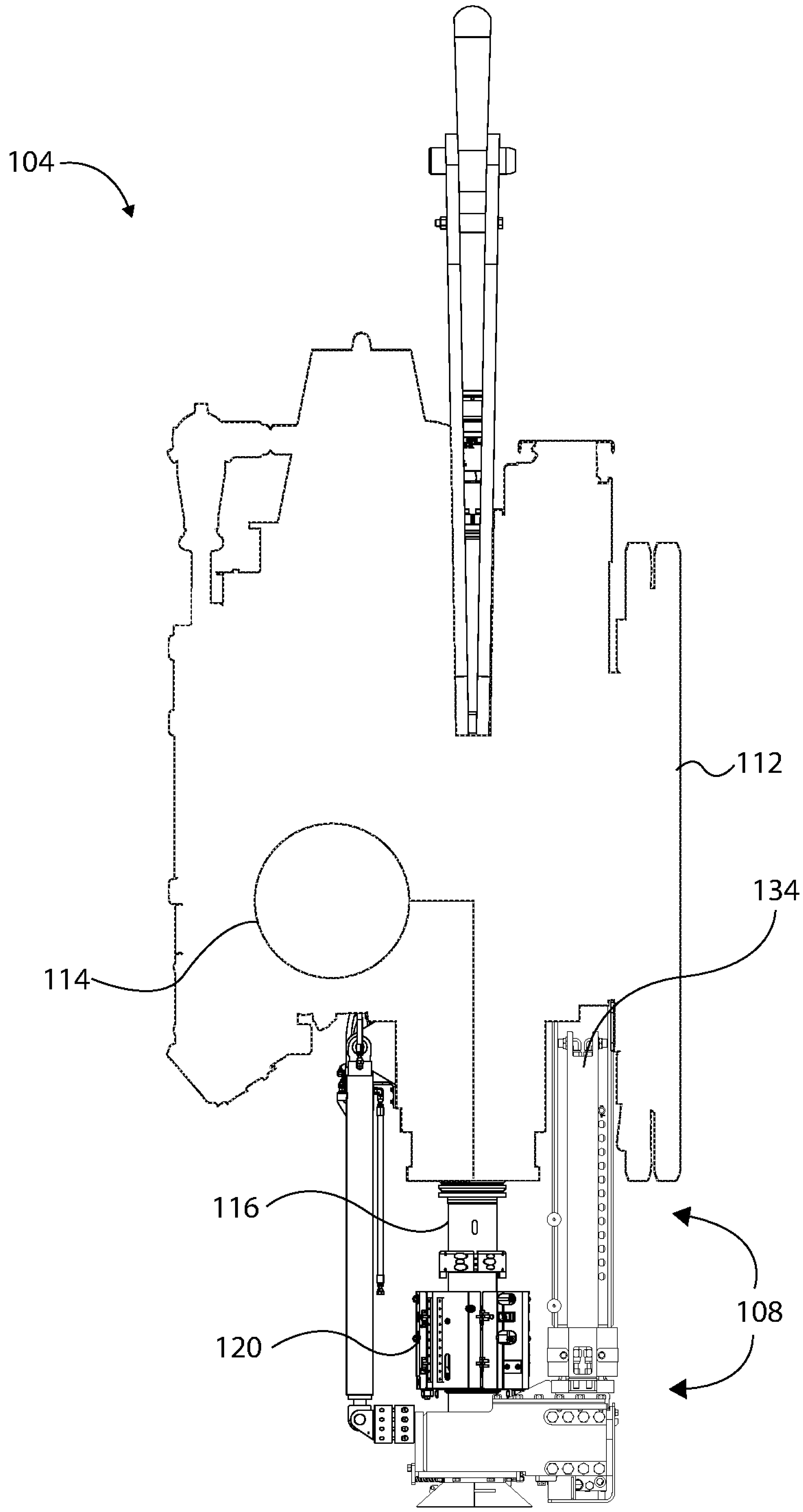


FIG. 2B

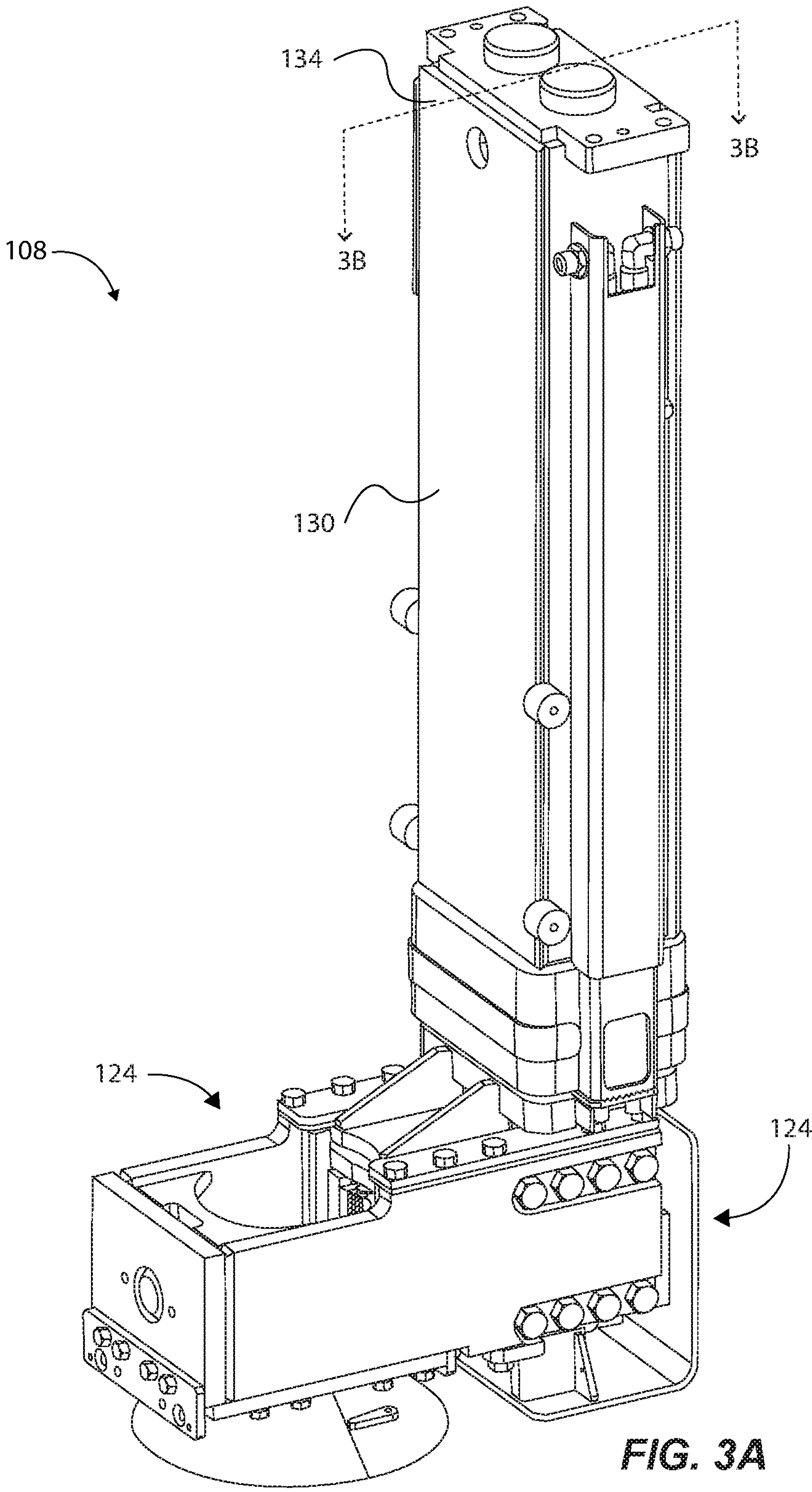
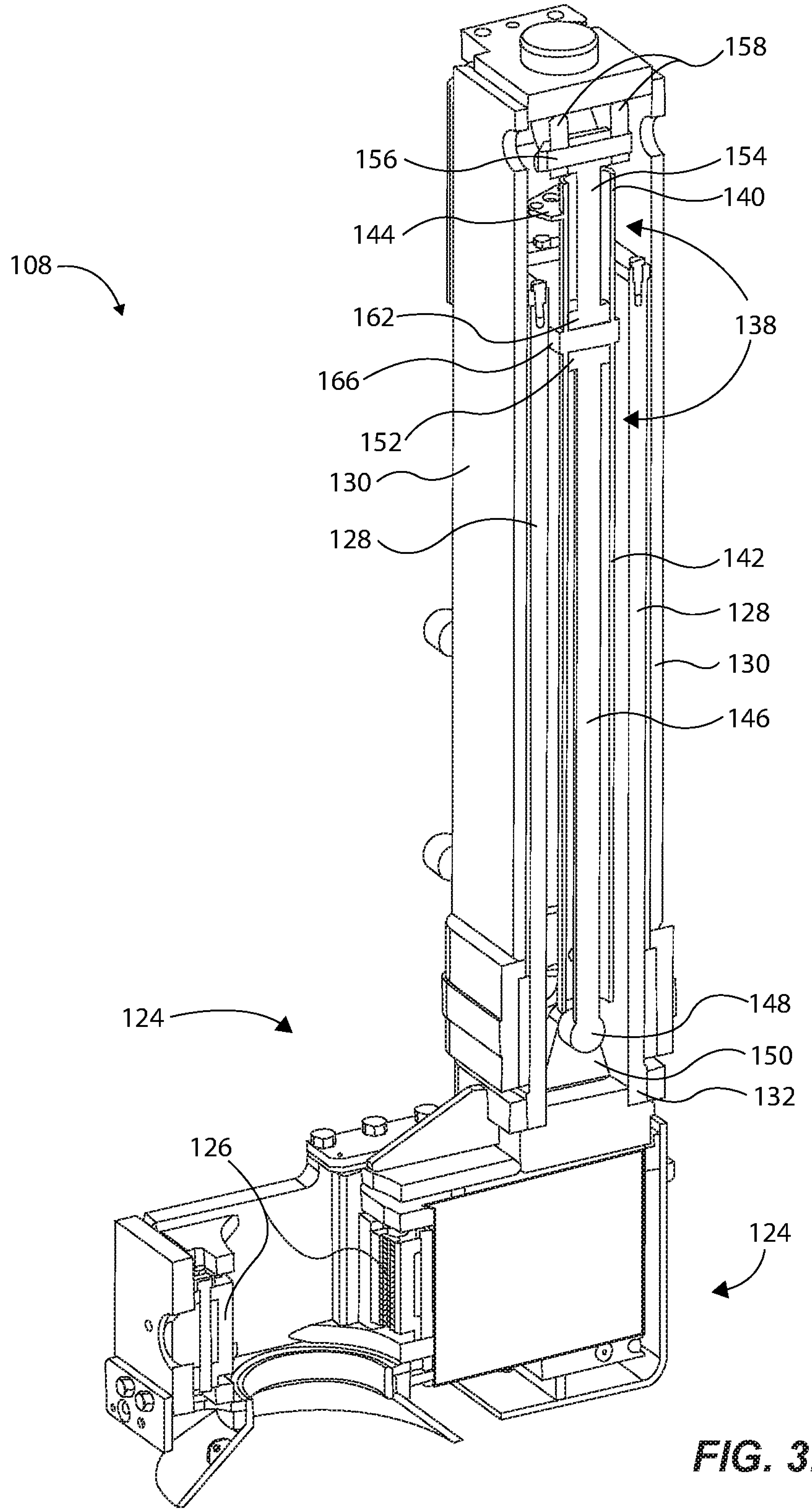


FIG. 3A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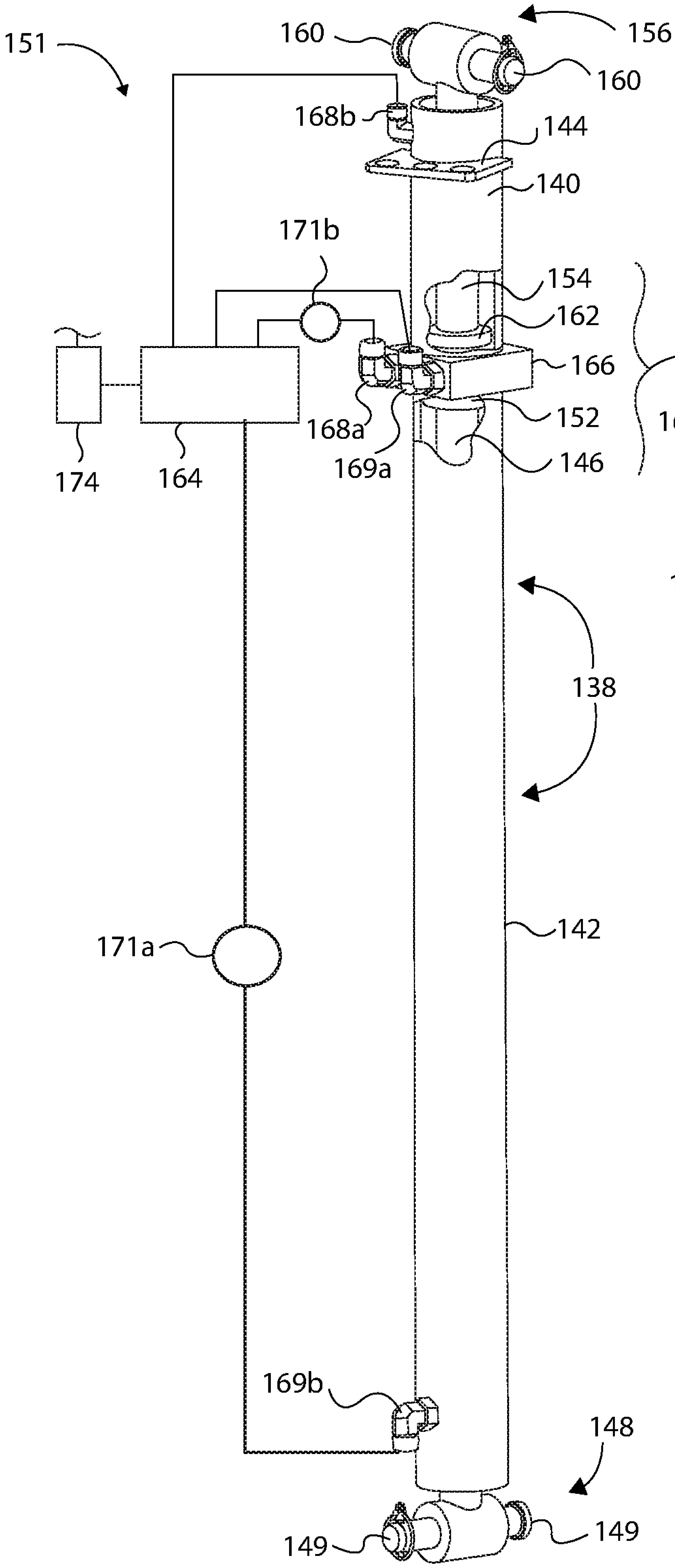
124

FIG. 3B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160
156
160
168b
144
140
171b
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168a
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169a
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174
164
138
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171a
169b
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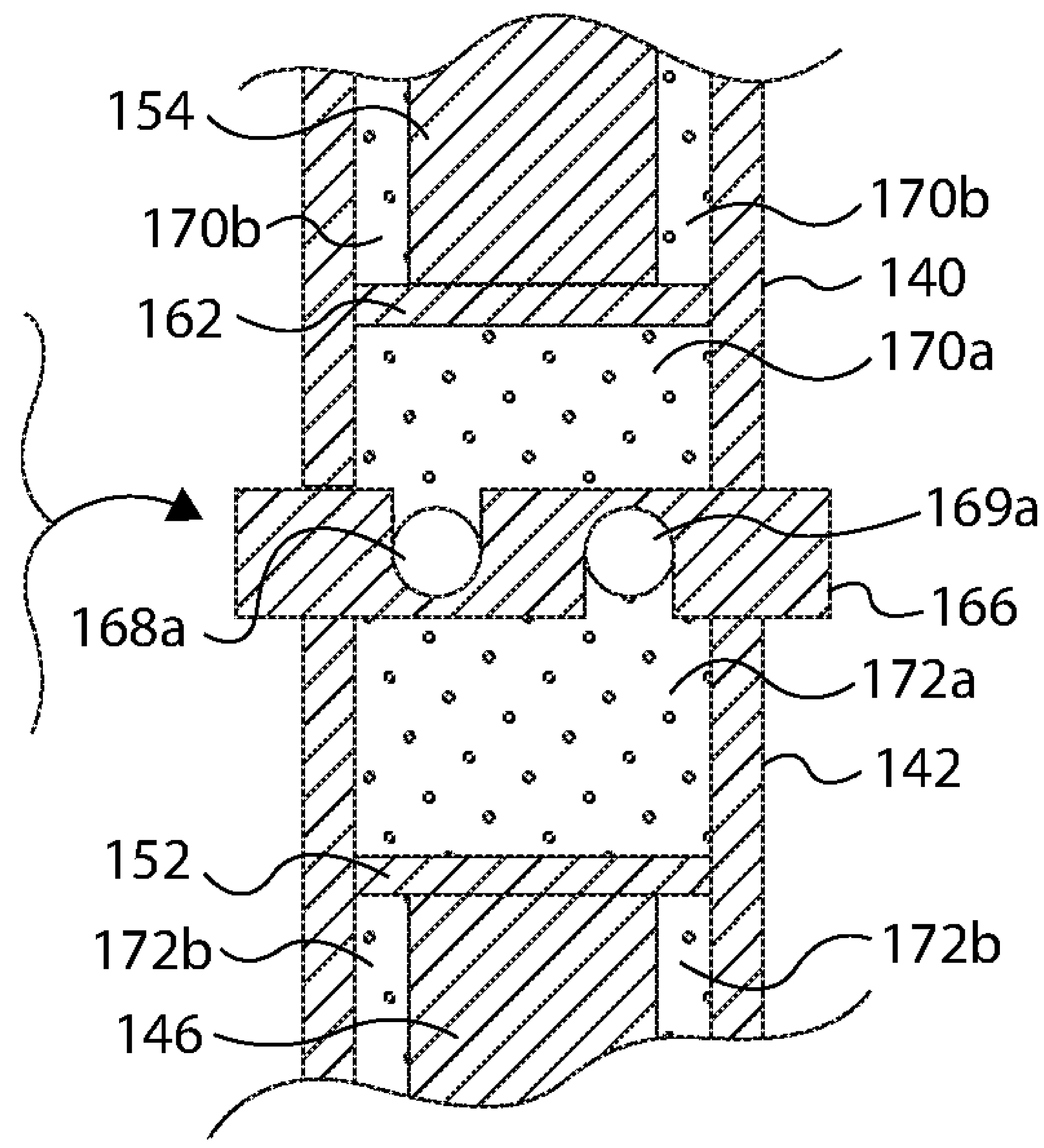
149
149

FIG. 4A


154
170b
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170a
169a
168a
166
172a
142
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172b
172b
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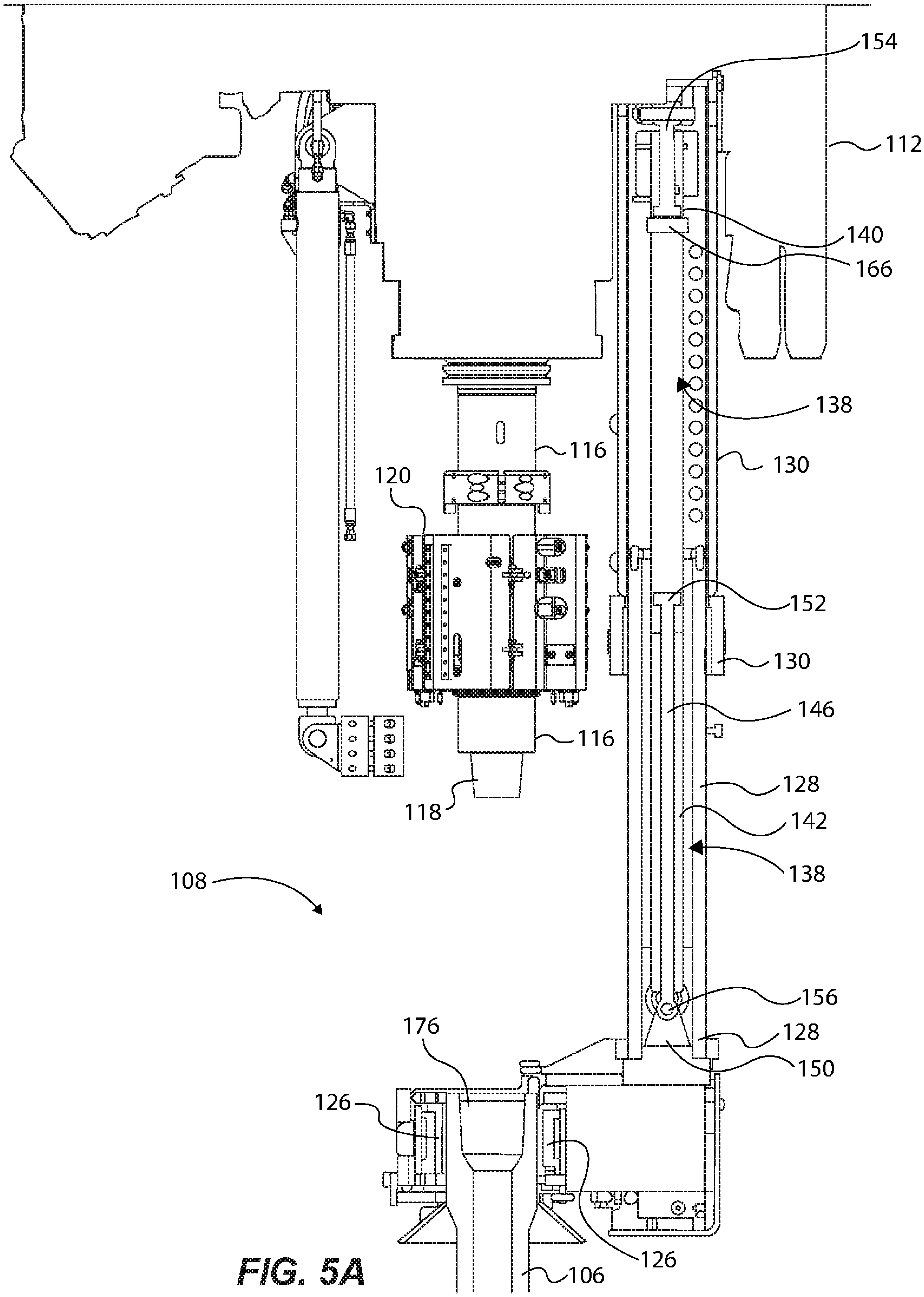
FIG. 4B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106

FIG. 5A

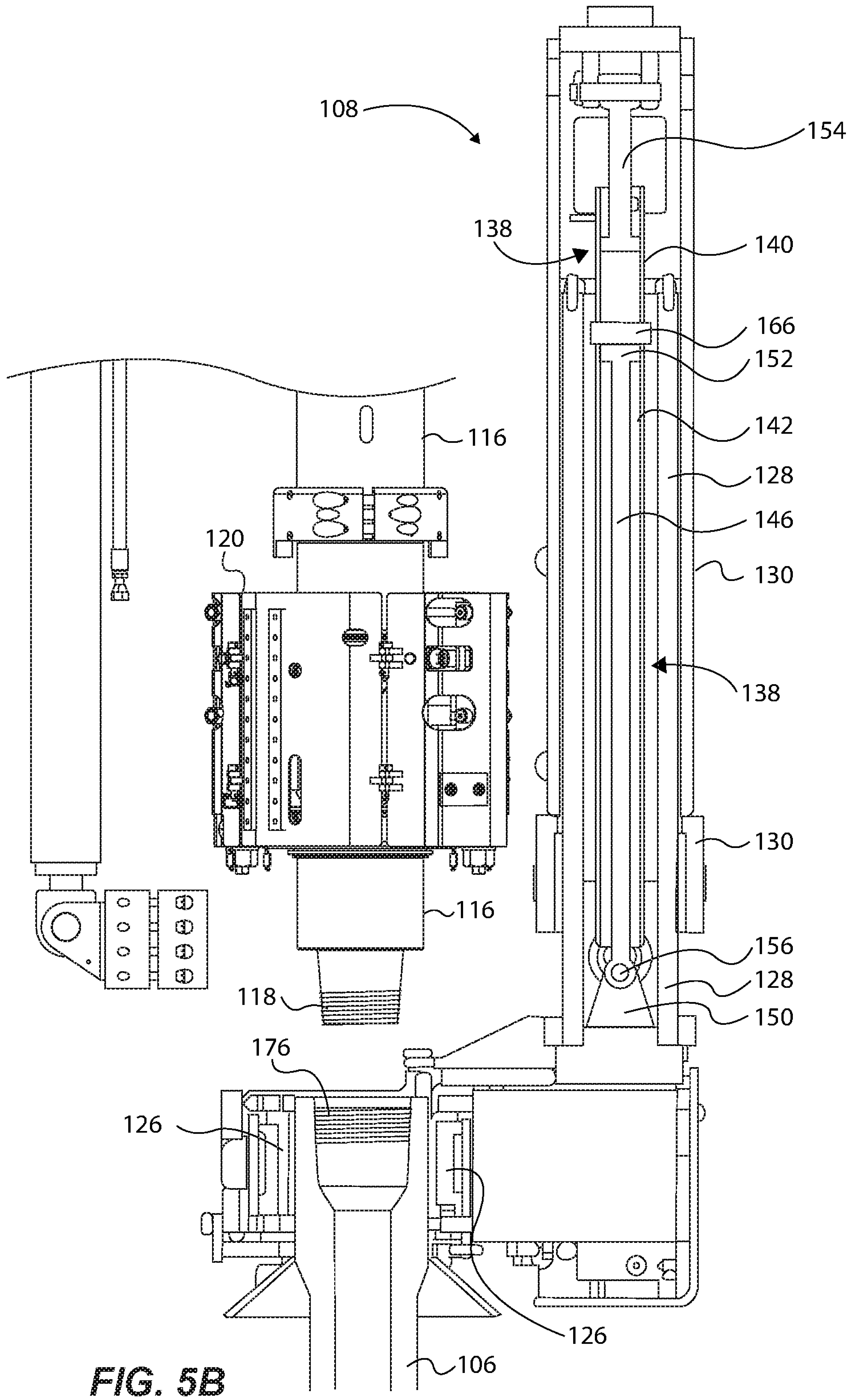
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FIG. 5B

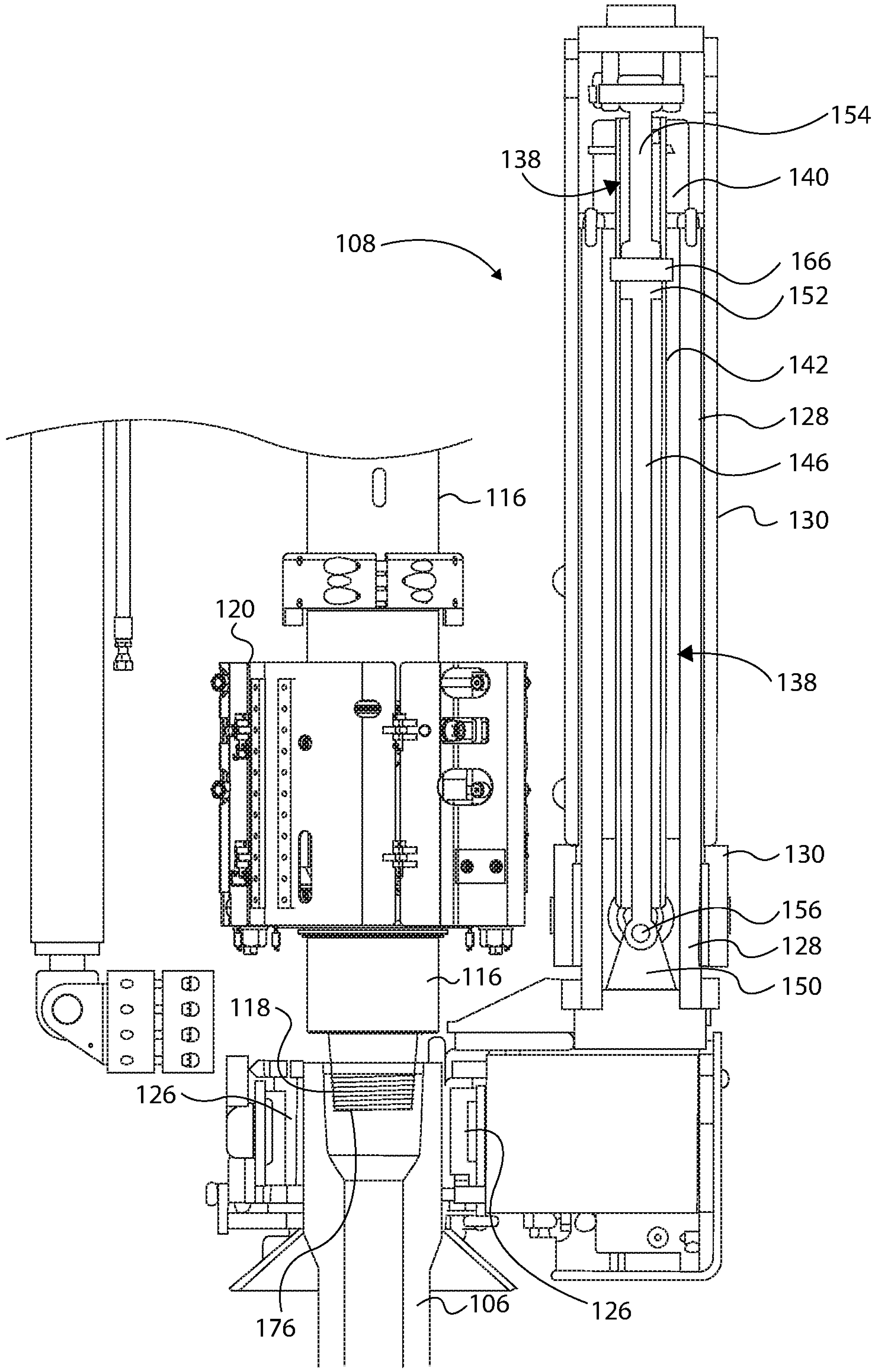
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FIG. 5C

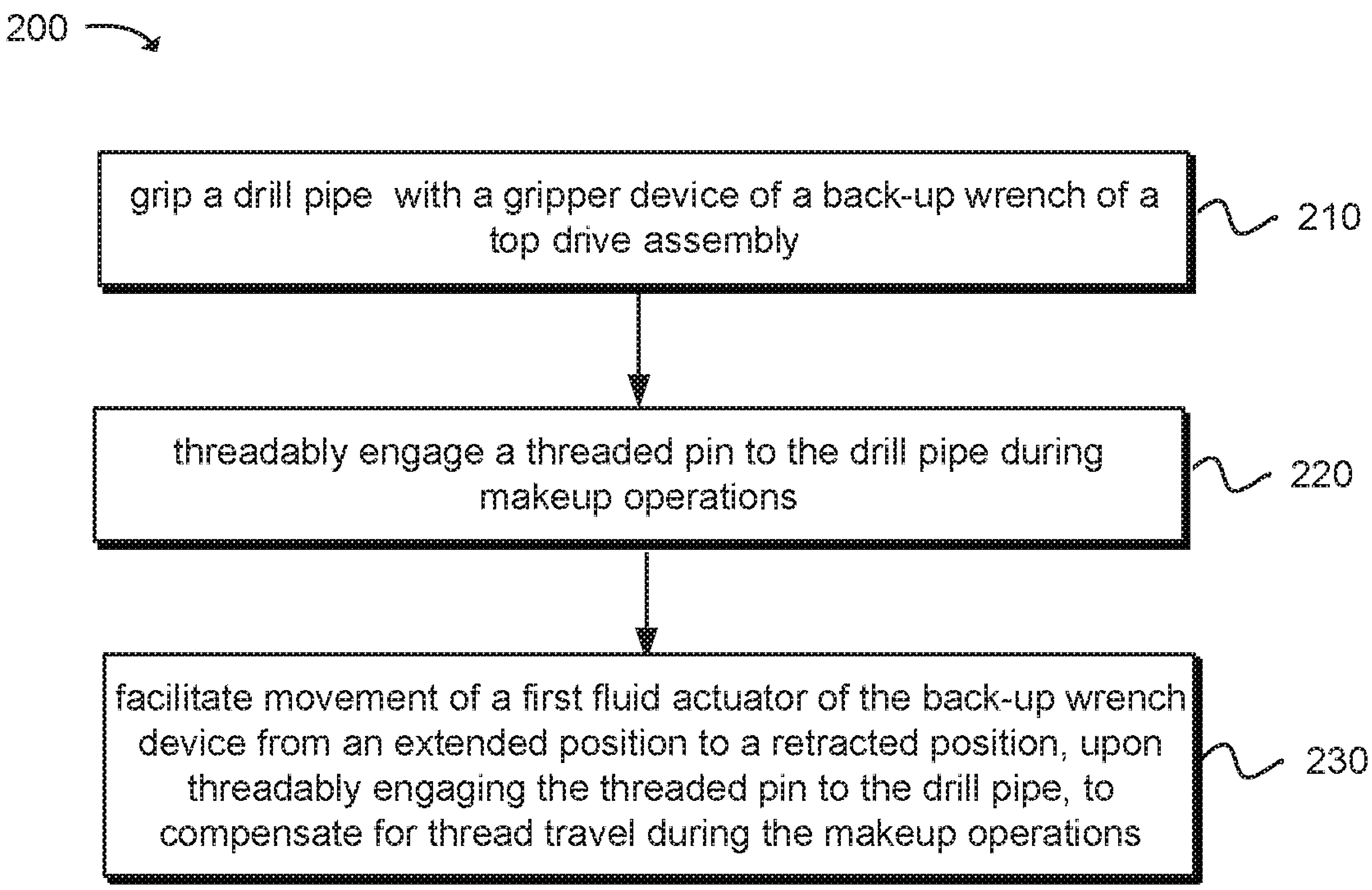
200
grip a drill pipe with a gripper device of a back-up wrench of a top drive assembly
210
threadably engage a threaded pin to the drill pipe during makeup operations
220
facilitate movement of a first fluid actuator of the back-up wrench device from an extended position to a retracted position, upon threadably engaging the threaded pin to the drill pipe, to compensate for thread travel during the makeup operations
230

FIG. 6

TOP DRIVE BACK-UP WRENCH WITH THREAD COMPENSATION

RELATED APPLICATION

This is a continuation application of U.S. application Ser. No. 15/859,607, filed Dec. 31, 2017, entitled "Top Drive Back-Up Wrench with Thread Compensation", which is incorporated by reference in its entirety herein.

BACKGROUND

Top drive drilling systems are well known in the art for drilling a wellbore for extracting subterranean natural resources from the earth. A top drive drilling system typically has a number of complex components including a top drive assembly supported by a derrick or drilling tower. A top drive assembly typically has a motor that rotates a main shaft that couples to a drill pipe for rotating a drill string (with a drill bit assembly) down a borehole. In some cases, the top drive assembly moves upwardly and downwardly on rails, or it can move via a cable/pulley system connected to the derrick. In either case, the top drive assembly is moved up and down about the derrick during drilling operations.

During drilling, the motor rotates the main shaft which, in turn, rotates the drill string and the drill bit assembly. Rotation of the drill bit produces the wellbore, often many miles into the earth. Drilling fluid (mud) is pumped into the top drive system and passes through an interior passage or conduit in the main shaft and through the drill string and to the drill bit assembly at the bottom of the wellbore.

In ordinary drilling operations of makeup of the top drive assembly to a drill pipe, the top drive assembly is hoisted up while pulling an unattached drill pipe for coupling to a stump (i.e., an upper end of a drill string in the earth). Once the unattached drill pipe is hoisted up and vertically oriented, a gripper device of the top drive assembly grips the female threaded end of the hoisted drill pipe. The top drive assembly rotates its main shaft (having a threaded pin/quill) clockwise for threadably mating the threaded pin of to the female end of the hoisted drill pipe while the gripper grips/positions the drill pipe. This is one "makeup" operation of the threaded pin to the drill pipe. With acme threads, for instance, about 2.5 inches of thread travel occurs during such makeup, which requires some amount of vertical travel of the top drive assembly in order to compensate for the thread travel as the threaded pin is threadably coupled to the drill pipe.

To compensate for such thread travel, existing systems utilize a simple spring configuration, whereby one or more springs are provided near the gripper assembly such that the spring(s) compress as the threads of threaded pin engage with the drill pipe. The spring(s) allow the top drive assembly to move vertically downward during threading, thereby compensating for the thread travel effectuated about the threaded pin and the drill pipe. The opposite holds true for breakout of the threaded pin from the drill pipe, whereby the spring(s) expand to compensate for thread travel during breakout operations (i.e., as the threaded pin is disengaged from drill pipe after the drill pipe has been drilled approximately 90 feet down with the drill string). Breakout is needed after the drill pipe has been drilled down a given distance so that the top drive assembly can hoist another drill pipe and repeat makeup operations.

However, such spring(s) are prone to failure because they often get clogged with mud and other debris because they are exposed to the environment. They are also unreliable and

can fail due to the amount of force and torque exerted by the top drive assembly onto the drill pipe. The spring(s) configuration can delay or halt drilling operations, which is very costly and problematic. Also, the spring(s) can exert unnecessary vertical tension to threads during makeup and breakout operations of the top drive assembly to and from a drill pipe, which can shorten the life of drill pipes and their threads.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the invention will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings; which together illustrate, by way of example, features of the invention; and, wherein;

FIG. **1** is a side view of a top drive assembly having a back-up wrench and which is suspended from a derrick in accordance with an example of the present disclosure;

FIG. **2**A is a side view of the top drive assembly of FIG. **1** without the back-up wrench;

FIG. **2**B is a side view of the top drive assembly of FIG. **1** with the back-up wrench;

FIG. **3**A is an isometric view of the back-up wrench of FIG. **1** in accordance with an example of the present disclosure;

FIG. **3**B is a cross sectional view of the back-up wrench of FIG. **3**A along lines B-B;

FIG. **4**A is an isometric view of a hydraulic housing and a hydraulic system of the back-up wrench of FIG. **3**A in accordance with an example of the present disclosure;

FIG. **4**B is a detailed cross-sectional view of a portion of the hydraulic housing of FIG. **4**A;

FIG. **5**A illustrates a cross-sectional view of the back-up wrench of FIG. **1**, with the gripper positioning actuator in an extended position;

FIG. **5**B illustrates a cross-sectional view of the back-up wrench of FIG. **1**, with the gripper positioning actuator in a retracted position, and with the thread compensation actuator in an extended position;

FIG. **5**C illustrates a cross-sectional view of the back-up wrench of FIG. **1**, with the gripper positioning actuator in a retracted position, and with the thread compensation actuator in a retracted position: and

FIG. **6** illustrates a method of operating a back-up wrench in accordance with an example of the present disclosure.

Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended.

DETAILED DESCRIPTION

As used herein, the term "substantially" refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is "substantially" enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained. The use of "substantially" is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result.

As used herein, “adjacent” refers to the proximity of two structures or elements. Particularly, elements that are identified as being “adjacent” may be either abutting or connected. Such elements may also be near or close to each other without necessarily contacting each other. The exact degree of proximity may in some cases depend on the specific context.

An initial overview of the inventive concepts is provided below and then specific examples are described in further detail later. This initial summary is intended to aid readers in understanding the examples more quickly, but is not intended to identify key features or essential features of the examples, nor is it intended to limit the scope of the claimed subject matter.

The present disclosure sets forth a back-up wrench device of a top drive assembly useable on a drilling rig. The back-up wrench device can comprise: a first housing coupleable to a support structure of a top drive assembly of a drilling rig; a second housing movably coupled to the first housing; a gripper device coupled to the second housing and operable to grip a drill pipe during makeup or breakout operations with the top drive assembly; and at least one fluid actuator coupled to one of the first housing or the second housing. During makeup or breakout operations, the at least one fluid actuator is movable to compensate for thread travel.

In one example, the at least one fluid actuator is configured to automatically move between the extended position and the retracted position via operation of a hydraulic system due to fluid pressure acting on the at least one fluid actuator during makeup or breakout operations.

In one example, the first and second housings are translatable relative to each other, and at least one of the first and second housings can enclose the at least one fluid actuator.

In one example, the back-up wrench comprises a primary hydraulic housing coupled to each of the first and second housings. The primary hydraulic housing comprises a lower fluid housing and an upper fluid housing fluidly separated from each other. The at least one fluid actuator can comprise a lower fluid actuator movable through the lower fluid housing, and an upper fluid actuator movable through the upper fluid housing.

The present disclosure sets forth a top drive system for use on a drilling rig comprising a top drive assembly movably coupleable to a rig support frame of a drilling rig. The top drive assembly comprises a threaded pin that is operable to rotatably engage and disengage a threaded end of a drill pipe during respective makeup and breakout operations. The top drive system comprises a back-up wrench device coupled to the top drive assembly and comprising a gripper device operable to grip the drill pipe, and at least one fluid actuator operable to compensate for thread travel between the threaded pin of the top drive assembly and the drill pipe during makeup or breakout operations.

The present disclosure sets forth a top drive system for use on a drilling rig comprising: a top drive assembly comprising a threaded pin that is operable to rotatably engage and disengage a threaded end of a drill pipe during respective makeup operations and breakout operations associated with the top drive assembly and the drill pipe, and a back-up wrench device coupled to the top drive assembly. The back-up wrench can comprise: a gripper device operable to grip the drill pipe; a first housing coupled to a support structure of the top drive assembly; a second housing coupled to the gripper device, and movably coupled to the first housing; and a primary hydraulic housing movably coupled to each of the first and second housings, and comprising an upper fluid chamber and a lower fluid chamber; an upper fluid actuator coupled to the first housing, and movable through the upper fluid chamber (the upper fluid actuator being operable from an extended position to a retracted position to compensate for thread travel between the threaded pin of and the drill pipe during makeup operations); and a lower fluid actuator coupled to the second housing, and movable through the lower fluid chamber (the lower fluid actuator being operable from a retracted position to an extended position to compensate for thread travel during breakout operations).

The present disclosure sets forth a method for thread compensation with a back-up wrench device of a top drive assembly of a drilling rig. The method can comprise: gripping a drill pipe with a gripper device of a back-up wrench of a top drive assembly; threadably engaging a threaded pin to the drill pipe during makeup operations; and facilitating movement of a first fluid actuator of the back-up wrench device from an extended position to a retracted position, upon threadably engaging the threaded pin to the drill pipe, to compensate for thread travel during the makeup operations.

The method can further comprise threadably disengaging the threaded pin from the threaded end of the drill pipe during breakout operations, and facilitating movement of a upper fluid actuator of the back-up wrench device from a retracted position to an extended position, upon threadably disengaging the threaded pin from the drill pipe, to compensate for thread travel during the breakout operations. The method can still further comprise operating a hydraulic system to move the upper fluid actuator from the retracted position to the extended position, and between makeup and breakout operations to reset the upper fluid actuator to the extended position.

To further describe the present technology, examples are now provided with reference to the figures.

FIGS. **1**-**2**B illustrate a drilling rig system **100** comprising a rig support frame **102** (e.g., a derrick) and a top drive assembly **104**, with a back-up wrench **108**, in accordance with an example of the present disclosure. FIGS. **2**A and **2**B show the top drive assembly **104** isolated from the rig support frame **102**, while FIG. **2**A shows the top drive assembly **104** without the back-up wrench device **108** for purposes of illustration.

The top drive assembly **104** comprises or is operable with the back-up wrench device **108** for gripping a drill pipe **106** of a drill string **109** (or to be coupled to a drill string) disposed through a ground surface. Notably, the back-up wrench device **108** is configured for thread travel compensation during each of drill pipe makeup operations and breakout operations, as further detailed below.

In one example, the top drive assembly **104** is tethered to the rig support frame **102** by a cable **110**, which can be coupled to a drum reel and motor (not shown) that is controlled to raise or lower the top drive assembly **104** into desired positions, as with typical drilling set ups having a top drive assembly. The top drive assembly **104** can comprise a support structure **112** that supports a variety of top drive drilling systems/components. For instance, the support structure **112** can comprise a number of steel frame supports that support a motor **114** (shown schematically) configured to rotate a main shaft **116** for rotating drill pipes of the drill string **109**. Of course, at the lower end of the drill string **109** includes a drill bit assembly (not shown) for drilling a borehole.

The motor **114** rotates the main shaft **116** that rotates a threaded pin **118** (FIG. **2**A) that, when coupled to the drill pipe **106**, rotates the drill pipe **106** to thereby rotate the drill string **109** for drilling the borehole. Drilling fluid (e.g., mud) is pumped into the top drive assembly **104** through a mud valve **120** (or multiple mud valves), and the mud passes through interior passages along the main shaft **116**, the threaded pin **118**, the drill string **109**, and then to the drill bit at the bottom of the borehole. As with typical mud drilling operations, a mud pump (not shown) pumps mud into the borehole in this manner, and then pumps it out for recirculation. The basic structure and operation of a top drive assembly is well known and will not be discussed in great detail. However, it will be appreciated that the top drive assembly **104** of the present disclosure can comprise a number of known devices and mechanisms to effectuate drilling operations, as discussed above.

During makeup of the threaded pin **118** to the drill pipe **106**, a stump (upper end of a drill pipe of a drill string) extends from the borehole (as being previously drilled into the ground by the top drive assembly **104**). Then, the top drive assembly **104** is hoisted up via the cable **110** while the top drive assembly **104** grabs and pulls another drill pipe from an inventory/stack of drill pipes. For purposes of illustration, assume drill pipe **106** was already hoisted into position for makeup of the threaded pin **118** to the drill pipe **106** during drilling operations. The back-up wrench device **108** is then utilized to assist with such makeup, as further discussed below.

FIG. **3**A shows an isometric view of the back-up wrench device **108**, and FIG. **3**B shows a cross sectional view of the back-up wrench device **108** along lines **3**B-**3**B of FIG. **3**A. With reference to FIGS. **1**-**3**B, the back-up wrench device **108** can comprise a gripper device **124** operable to grip an end of the drill pipe **106**. The gripper device **124** can comprise gripping members **126** (e.g., in one example, see gripping members **126** in the form of gripping teeth in FIG. **3**B) that can be hydraulically actuated by a hydraulic system (not shown) to grip or release the outer surface of the drill pipe **106** during makeup and breakout operations, as further discussed below.

In one example, the back-up wrench device **108** can comprise an inner or first housing **128** (FIG. **3**B) attached to the gripper device **124** and an outer or second housing **130** coupled or otherwise secured to a portion of the support structure **112** of the top drive assembly **104** (see FIG. **1**; see also FIGS. **5**A and **5**B showing the inner and outer housings **128** and **130**). As shown in FIG. **3**B, a lower end **132** of the inner housing **128** is coupled (fastened, welded, or otherwise secured) to structural support plates/frames of the gripper device **124**. The gripper device **124** can include a number of plates and other structural support members bolted or welded together, for instance, to support and house various gripper mechanisms therein. In one example, as shown, the back-up wrench device **108** can comprise a somewhat L-shaped configuration to position the gripping members **126** away from the inner and outer housings **128** and **130**, such that the longitudinal axis of the drill pipe **106** is generally or substantially parallel to a longitudinal axis the inner and outer housings **128** and **130**. In this configuration, the thread compensation axis (the axis of movement of the components of the thread compensation device) can be offset from the longitudinal axis of the drill pipe and drill string as well as the main shaft of the top drive.

An upper end **134** of the outer housing **130** can be attached to a portion of the support structure **112** in a suitable manner, such as with bolts or other attachment or securing means. Both the inner and outer housings **128** and **130** can be comprised of steel and can each have a corresponding cross sectional area (e.g., a square or rectangular-shaped cross-sectional area), configured to resist a high amount of torque on the system during makeup and breakout operations while the gripper device **124** grips the drill pipe **106**. As further discussed below, the inner housing **128** is movable or translatable axially relative to the outer housing **130**, such as in a telescoping manner.

With reference to FIGS. **1**-**4**B, the back-up wrench device **108** can further comprise a primary hydraulic housing **138** coupled to the inner and outer housings **128** and **130**. More specifically, the primary hydraulic housing **138** can comprise a lower fluid housing **140** and an upper fluid housing **142** fluidly separated from each other (by a partition, as discussed below). The primary hydraulic housing **138** can comprise a positioning plate **144** secured to the upper end of the primary hydraulic housing **138** adjacent the upper fluid housing **140**. The positioning plate **144** can be sized corresponding to the inner surface of the inner housing **128** and can be sized slightly smaller than the inner surface of the inner housing **128** so that, as the primary hydraulic housing **138** moves, the positioning plate **144** slides along the inner surface of the inner housing **128** to assist with properly (e.g., vertically) orienting the primary hydraulic housing **138** within the inner and outer housings **128*a*** and **130**. Thus, in one example, the primary hydraulic housing **138** can be movably coupled to both of the inner and outer housings **128** and **130**, as will be appreciated from the below discussion.

The back-up wrench device **108** can further comprise a lower or first fluid actuator **146** having one end coupled to the inner housing **128** and the other end movably disposed through the lower fluid housing **142** upon being hydraulically actuated (discussed further below regarding FIG. **5**). In one example, the lower fluid actuator **146** can comprise a steel cylinder having first and second ends. The lower fluid actuator **146** can be rotatably coupled to the gripper device **124**. In the example shown, for instance, the lower fluid actuator **146** can comprises, at a rod end, a coupling member **148** rotatably coupled to a pair of support flanges **150** (one shown in FIG. **3**B) of the gripper device **124**. Each support flange **150** can comprise an aperture configured to receive respective, and opposing protruding posts **149** (FIG. **4**A) of the coupling member **148**. With this arrangement, the lower fluid actuator **146** is essentially "pinned" to the gripper device **124** to allow some relative rotational movement (about a rotational axis (e.g., a z-axis (axis extending out of the page)) of the gripper device **124** relative to the support structure **112** of the top drive assembly **104** as the gripper device **124** is being positioned for gripping a drill pipe (because drill pipes of a drill string are not always perfectly, vertically aligned as extending from the ground).

An upper or piston end of the lower fluid actuator **146** includes a piston head **152** (FIGS. **3**B-**4**B) that is slidably movable through the lower fluid housing **142** of the primary hydraulic housing **138** upon the application of hydraulic fluid pressure that causes movement of the lower fluid actuator **146** between retracted and expanded or extended positions, as further discussed below.

The back-up wrench device **108** can further comprise a second or upper fluid actuator **154**. In one example, the upper fluid actuator **154** can comprise a coupling member **156** (FIG. **4**B) rotatably coupled to a pair of support flanges **158** (FIG. **3**B) of the outer housing **130** that each have an aperture that receives respective posts **160** of the coupling member **156**. Thus, the upper fluid actuator **154** is "pinned" to the outer housing **130** to allow some relative rotational movement (about a rotational axis) of the gripper device **124** relative to the support structure **112** as the gripper device **124** is being positioned for gripping a drill pipe. A lower or piston end of the upper fluid actuator **154** includes a piston head **162** that is slidably movable through the upper fluid housing **140** of the primary hydraulic housing **138** upon the application of hydraulic fluid pressure that causes movement of the upper fluid actuator **154** between retracted and expanded positions, as discussed below.

A hydraulic system **151** (see specifically FIG. **4**A) can be included and configured to actuate or facilitate movement of the lower fluid actuator **146** and, independently, the upper fluid actuator **154**. The hydraulic system **151** can comprise a hydraulic mechanism **164** that can include one or more hydraulic pumps, manifold(s), fluid lines, valves, regulators, etc. In one example, the primary hydraulic housing **138** comprises a partition manifold structure **166** that separates the upper and lower fluid housings **140** and **142**, and consequently that separates the piston head **152** of the lower fluid actuator **146** and the piston head **162** of the upper fluid actuator **154**.

The partition manifold structure **166** can comprise a first hydraulic port **168***a* in fluid communication with a lower chamber **170***a* of the upper fluid housing **140**, and a second hydraulic port **169***a* in fluid communication with an upper chamber **172***a* of the lower fluid housing **142**. The primary hydraulic housing **138** can further comprise a third hydraulic port **168***b* in fluid communication with an upper chamber **170***b* of the upper fluid housing **140**, and a fourth hydraulic port **169***b* in fluid communication with a lower chamber **172***b* of the lower fluid housing **142**. As best illustrated in the cross sectional view of FIG. **4**B, the piston head **162** of the upper fluid actuator **154** fluidly separates (i.e., seals off) the upper and lower chambers **170***a* and **170***b* of the upper fluid housing **140**. Likewise, the piston head **152** of the lower fluid actuator **146** fluidly separates the upper and lower chambers **172***a* and **172***b* of the lower fluid housing **142**. For purposes of illustration, note that the positions of the respective piston heads **152** and **162** are shown in FIG. **4**B as being positioned away from the partition manifold structure **166** in order to show the various fluid chambers discussed above, but in practice during makeup and breakout the piston heads **152** and **162** may be in the positions shown in the figures discussed below.

An upper seal device (not shown) can be disposed in the upper fluid housing **140** adjacent hydraulic port **168***b* to seal off fluid contained in the upper chamber **170***b*. Likewise, a lower seal device can be disposed in the lower fluid housing **142** adjacent hydraulic port **169***b* to seal off fluid contained in the lower chamber **172***b*.

The hydraulic mechanism **164** is fluidly coupled to each of the hydraulic ports **168***a*, **168***b*, **169***a*, and **169***b* via fluid lines for transferring fluid to or from respective chambers (**170***a*, **170***b*, **172***a*, **172***b*) of the primary hydraulic housing **138**. The hydraulic mechanism **164** can be coupled to a hydraulic control system **174** for controlling operation of the hydraulic mechanism **164**. The hydraulic control system **174** can be a computer system and/or a manual control panel. In one example, an operator controls the hydraulic mechanism **164** via a plurality of computer controlled commands executable via the hydraulic control system **174** for separate control and actuation of each of the upper fluid actuator **154** and the lower fluid actuator **146** between their respective expanded and retracted positions, as further discussed below. In another example discussed below, the lower fluid actuator **146** may be actuated automatically or passively upon threadably disengaging the threaded pin **118** from the drill pipe **106** during breakout operations, for instance.

Operating hydraulic pumps and related mechanisms is well known and will not be discussed in great detail. However, in one example hydraulic ports **168***a* and **168***b* can be fluidly coupled in a closed loop hydraulic system (e.g., via a hydraulic pump) such that fluid pressure can be supplied via hydraulic port **168***a* and concurrently removed via hydraulic port **168***b* to cause movement of the upper fluid actuator **154** from the retracted position and the expanded position, whether actively actuated by a hydraulic pump or passively actuated due to fluid pressure applied to the upper fluid actuator **154**, as further detailed below. Similarly, hydraulic ports **169***a* and **169***b* can be fluidly coupled in a closed loop hydraulic system (e.g., via a hydraulic pump) such that fluid pressure can be supplied via hydraulic port **169***a* and concurrently removed via hydraulic port **169***b* to cause movement of the lower fluid actuator **146**, such as from the retracted position to the expanded position, whether actively actuated by a hydraulic pump or passively actuated due to fluid pressure applied to the lower fluid actuator **146**, as further detailed below.

With reference to FIGS. **1**-**50**, the top drive assembly **104** (and its threaded pin **118**) can be moved relative to the gripper device **124** during makeup and breakout operations by controlling the hydraulic mechanism **164** to actuate the lower fluid actuator **146** or the upper fluid actuator **154** or both. Specifically, and in one example, during breakout operations the lower fluid actuator **146** can be moved from the retracted position to the expanded position (FIG. **5**A) by supplying fluid pressure into the upper chamber **172***a* via hydraulic port **169***a*. Thus, fluid pressure is exerted against/above the piston head **152** to downwardly move the lower fluid actuator **146** through the primary hydraulic housing **138** relative to the outer housing **130** (and relative the attached support structure **112**). In one example involving passive actuation of the lower fluid actuator **146** during breakout operations, a rod-side relief valve **171***a* can be in fluid communication with fluid in the lower chamber **172***b*, so that upon sufficient fluid pressure in the upper chamber **172***a* (thereby downwardly biasing the piston head **152**), the rod-side relief valve **171***a* is caused to be opened to permit removal of fluid from the lower chamber **172***b*, thereby permitting the lower fluid actuator **146** to move to the extended position. The "sufficient fluid pressure" is the result of the force applied to the fluid in the upper chamber **172***a* as a result of the threaded pin **118** being threadably disengaged from the drill pipe **106**. That is, the axial movement of the top drive assembly **104** away from the drill pipe **106**, due to being threadably disengaged therefrom, causes an increase in pressure in the fluid in the upper chamber **172***a*, which causes downward movement or actuation of the lower fluid actuator **146** concurrently along with axial displacement of the threaded pin **118** away from the drill pipe **106**. During these breakout operations, the upper fluid actuator **154** may be in the extended position (until makeup operations are performed, as detailed below). After disengagement of the threaded pin **118** from the drill pipe **106**, the top drive assembly **104** can be hoisted upwardly to further cause downward movement of the lower fluid actuator **146** to the position shown in FIG. **5**A. Such downward movement of the lower fluid actuator **146** can extend the gripper device **124** relatively far away from the threaded pin **118**. It is noteworthy to mention that, in this position, additional mud valves can be attached to the main shaft, and servicing can be performed on the system.

During makeup operations, the threaded pin **118** (e.g., male configuration having acme threads) is positioned near a threaded end **176** (e.g., female configuration having acme threads) of the drill pipe **106**, then the main shaft **116** can be rotated to "makeup" or threadably engage the threaded pin **118** to the drill pipe **106**, while the gripper device **124** grips the drill pipe **106** (as discussed above). During such threadable engagement, the upper fluid actuator **154** can be moved from the expanded position (FIG. **5**B) to the retracted position (FIG. **5**C) by supplying fluid pressure into the upper chamber **170***b* via hydraulic port **168***b* while removing fluid from the lower chamber **170***a*. Such transfer of fluid via ports **168***a* and **168***b* can be performed actively via manual control or programmed control that removes and supplies fluid pressure to respective chambers **170***b* and **170***a*, or it can be performed passively via relief valves.

For instance, a piston-side relief valve **171***b* can be in fluid communication with the lower chamber **170***a* via hydraulic port **168***a*, so that upon sufficient fluid pressure in the upper chamber **170***b* (thereby biasing downwardly the piston head **162**), the piston-side relief valve **171***b* is caused to be opened to remove fluid from the lower chamber **170***a* to move the upper fluid actuator **154** from the extended position to the retracted position while the threaded pin **118** is being threadably engaged with the drill pipe **106** (i.e., makeup operations).

Advantageously, in this manner the upper fluid actuator **154** compensates for thread travel (between the threaded pin **118** and the threaded end **176** of the drill pipe **106**) during makeup operations, as outlined above. And, the lower fluid actuator **146** can compensate for thread travel during breakout operations, as outlined above. However, in one example, only one fluid actuator may be used during both breakout and makeup operations. For instance, only the lower fluid actuator **146** may be incorporated into a single chamber hydraulic housing/cylinder for both breakout and makeup operations. In this example, more precise manual control over the position of the lower fluid actuator **146** via a hydraulic system controller may be required to properly coordinate movement of the fluid actuator with the axial movement of the top drive assembly relative to a drill pipe.

In some examples, the aforementioned "thread travel" can be several inches (e.g., a thread distance of approximately 2.5 inches, which is the thread height of typical acme threads used in many borehole drilling applications). However, the thread distance can vary depending on the particular thread height of a drill pipe, such as about 1 inch up to 5 inches or more of thread travel.

During makeup, once the threaded pin **118** is fully engaged with the threaded end **176** of the drill pipe **106**, the gripper device **124** is caused to release gripping pressure from the drill pipe **106**, and then the main shaft **116** is rotated clockwise to threadably engage a lower threaded male end (not shown) of the drill pipe **106** to a stump. Downhole drilling operations then continue on the drill string (e.g., about 90 feet downwardly) until the upper end of a drill pipe **106** is again extending out of the ground surface. Then, the gripper device **124** is engaged to again grip the drill pipe **106**, and then the main shaft **116** is rotated counter clockwise until the threaded pin **118** is disengaged from the threaded end **176** of the drill pipe **106** (i.e., breakout of the drill pipe). After breakout of the drill pipe **106**, the upper fluid actuator **154** can be hydraulically actuated back to its expanded position via active actuation, such as by a manual operator. Thus, the upper fluid actuator **154** can be ready and positioned for makeup of another drill pipe during normal drilling operations.

Upon contacting the drill pipe **106**, the main shaft **116** can be axially movable or can axially "float" during makeup and breakout to avoid damage to the threaded pin **106** and the main shaft **116**, which can be achieved via springs or other compliant devices that allow the main shaft **116** to float in this manner.

Thus, during breakout operations, the lower fluid actuator **146** can be simultaneously hydraulically actuated from the retracted position to the expanded position in a coordinated manner as the threaded pin **118** is disengaged from the drill pipe **106** to breakout the top drive assembly **104**. The gripper device **124** can then be operated to release gripping pressure, and then another section of a drill pipe (e.g., from inventory/stack) can be hoisted up by the top drive assembly **104**. The makeup process described above (regarding FIGS. **5**A-**50**) can be repeated for the new drill pipe to be coupled with the drill pipe **106** as part of the drill string, and this can be repeated for hundreds of drill pipes during downhole drilling operations.

Advantageously, the lower and upper fluid actuators **146** and **154** are housed or contained entirely inside the walls of the inner and outer housings **128** and **130**, which prevents mud and other debris from interfering with proper operation of the fluid actuators **146** and **154**. Another advantage is that the upper actuator **154** is positioned at an upper end of the back-up wrench **108**, at a location relatively far away and distal from the gripper device **124** where mud typically abounds during makeup and breakout. This further minimizes the amount of debris that could affect operation of the upper fluid actuator **154**.

FIG. **6** illustrates a method **200** for thread compensation for a back-up wrench device of a top drive assembly of a drilling rig in accordance with an example of the present disclosure. At operation **210**, the method comprises gripping a drill pipe (e.g., **106**) with a gripper device (e.g., **124**) of a back-up wrench (e.g., **108**) of a top drive assembly (e.g., **104**), such as described above regarding the devices and method used for gripping a drill pipe. At operation **212**, the method comprises threadably engaging a threaded pin (e.g., **118**) of the top drive assembly during makeup operations. This can be achieved by operating the motor and main shaft discussed above regarding the top drive assembly of FIGS. **1**-**5**C. At operation **214**, the method comprises facilitating movement of a first fluid actuator (e.g., **154**) of the back-up wrench device from an extended position to a retracted position, upon threadably engaging the threaded pin to the drill pipe, to compensate for thread travel during the makeup operations. This can be achieved with the devices and methods discussed regarding FIGS. **3**A-**5**C.

Reference was made to the examples illustrated in the drawings and specific language was used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the technology is thereby intended. Alterations and further modifications of the features illustrated herein and additional applications of the examples as illustrated herein are to be considered within the scope of the description.

Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more examples. In the preceding description, numerous specific details were provided, such as examples of various configurations to provide a thorough understanding of examples of the described technology. It will be recognized, however, that the technology may be practiced without one or more of the specific details, or with other methods, components, devices, etc. In other instances, well known structures or operations are not shown or described in detail to avoid obscuring aspects of the technology.

Although the subject matter has been described in language specific to structural features and/or operations, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features and operations described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims. Numerous modifications and alternative arrangements may be devised without departing from the spirit and scope of the described technology.

What is claimed is:

1. A back-up wrench device of a top drive assembly useable on a drilling rig, comprising:
- a first housing coupleable to a support structure of the top drive assembly of the drilling rig;
- a second housing movably coupled to the first housing;
- a gripper device coupled to the second housing and operable to grip a drill pipe of a drill string during at least one of makeup operations or breakout operations while the top drive assembly respectively threadably attaches or detaches a threaded pin of the top drive assembly to the drill pipe;
- at least one fluid actuator coupled to one of the first housing or the second housing, wherein, during at least one of the makeup or breakout operations, the at least one fluid actuator is movable to compensate for thread travel; and
- a primary hydraulic housing coupled to each of the first and second housings, the primary hydraulic housing comprising a fluid chamber, the at least one fluid actuator being movable through the fluid chamber during at least one of the makeup or breakout operations.

2. The back-up wrench of claim **1**, wherein the at least one fluid actuator is configured to move between an extended position and a retracted position.

3. The back-up wrench of claim **2**, wherein the at least one fluid actuator is configured to automatically move between the extended position and the retracted position via operation of a hydraulic system due to fluid pressure acting on the at least one fluid actuator.

4. The back-up wrench of claim **1**, wherein the first and second housings are translatable relative to each other, wherein at least one of the first and second housings encloses the at least one fluid actuator.

5. The back-up wrench of claim **1**, wherein the first and second housings enclose the primary hydraulic housing.

6. The back-up wrench of claim **1**, wherein the at least one fluid actuator comprises a piston head that separates the fluid chamber into an upper fluid chamber and a lower fluid chamber of the primary hydraulic housing, wherein upon fluid pressure being applied to one of the lower or upper fluid chambers, the piston head moves through the fluid chamber of the primary hydraulic housing to compensate for thread travel.

7. A top drive system for use on a drilling rig, comprising:
- a top drive assembly movably coupleable to a rig support frame of the drilling rig, the top drive assembly comprising a threaded pin that is operable to rotatably engage and disengage a threaded end of a drill pipe of a drill string during respective makeup and breakout operations; and
- a back-up wrench device coupled to the top drive assembly, comprising:
  - a gripper device operable to grip the drill pipe of the drill string while the top drive assembly threadably engages or disengages the threaded pin of the top drive assembly to the drill pipe during the respective makeup and breakout operations;
  - at least one fluid actuator operable to compensate for thread travel between the threaded pin of the top drive assembly and the drill pipe during at least one of the makeup or breakout operations;
  - a first housing coupled to a support structure of the top drive assembly;
  - a second housing coupled to the gripper device, and movably coupled to the first housing; and
  - a primary hydraulic housing coupled to each of the first and second housings, such that the first and second housings enclose the primary hydraulic housing, the at least one fluid actuator being movable through a fluid chamber of the primary hydraulic housing during at least one of the makeup or breakout operations.

8. The top drive system of claim **7**, wherein the at least one fluid actuator is configured to move between an extended position and a retracted position upon fluid pressure acting on the at least one fluid actuator.

9. The top drive system of claim **7**, wherein the at least one fluid actuator comprises a piston head that separates the fluid chamber into an upper fluid chamber and a lower fluid chamber of the primary hydraulic housing, wherein upon fluid pressure being applied to one of the lower or upper fluid chambers, the piston head moves through the fluid chamber of the primary hydraulic housing to compensate for thread travel.

10. The top drive system of claim **9**, further comprising a hydraulic system operatively coupled to the upper and lower fluid chambers of the primary hydraulic housing, wherein the piston head is configured to automatically move between an extended position and a retracted position via operation of the hydraulic system due to fluid pressure acting on the piston head.

11. A top drive system for use on a drilling rig, comprising:
- a top drive assembly comprising a threaded pin that is operable to rotatably engage and disengage a threaded end of a drill pipe of a drill string during respective makeup operations and breakout operations associated with the top drive assembly and the drill pipe;
- a back-up wrench device comprising:
  - a gripper device operable to grip the drill pipe of the drill string while the top drive assembly threadably engages or disengages the threaded pin of the top drive assembly to the drill pipe during the respective makeup and breakout operations;
  - a first housing coupled to a support structure of the top drive assembly;
  - a second housing coupled to the gripper device, and movably coupled to the first housing; and
  - at least one fluid actuator coupled to one of the first housing or the second housing, wherein, during makeup or breakout operations, the at least one fluid actuator is movable to compensate for thread travel between the threaded pin and the drill pipe; and
- a hydraulic system operatively coupled to upper and lower fluid chambers of a primary hydraulic housing

coupled to each of the first and second housings, the hydraulic system operable to facilitate actuation of the at least one fluid actuator.

12. The top drive system of claim **11**, wherein the at least one fluid actuator is configured to move between an extended position and a retracted position.

13. The top drive system of claim **12**, wherein the at least one fluid actuator is configured to automatically move between the extended position and the retracted position via operation of the hydraulic system due to fluid pressure acting on the at least one fluid actuator during the makeup or breakout operations.

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